In light of the foregoing, the application is now believed to be in proper form for allowance of all claims and notice to that effect is earnestly solicited. Please charge any deficiency or credit any overpayment to Deposit Account No. 10-1250.

Respectfully submitted,
JORDAN AND HAMBURG LLP

By _____
C. Bruce Hamburg
Reg. No. 22,389
Attorney for Applicants

and,

By _____
Herbert F. Ruschmann
Reg. No. 35,341
Attorney for Applicants

Jordan and Hamburg LLP
122 East 42nd Street
New York, New York 10168
(212) 986-2340

enc: Replacement sheets of Figs. 8-12; Substitute Specification; and Marked reproduction of original specification.

REMARKS

Claims 4-11 are now in this application. Claims 1-3 are rejected. Claims 1-3 are cancelled. New claims 4-11 are added.

Proposed replacement sheets of Figs. 8-12 wherein legends "PRIOR ART" are added are appended hereto.

The Office Action requests cooperation in correcting errors in the specification. Applicant submits herewith a substitute specification and abstract wherein amendments are effected to place the text thereof into proper English in accordance with 37 CFR 1.125(c). Also accompanying this amendment is a reproduction of the original specification and abstract with markings indicating the amendments effected in the substitute specification in accordance with MPEP §608.01(q) and 37 CFR 1.125(b). No new matter is added. Entry of the substitute specification and abstract is respectfully requested.

Claims 2 and 3 are rejected as indefinite under 35 U.S.C. § 112, second paragraph, for failing to particularly point out and distinctly claim the subject matter of the invention as a result of informalities stated in the Office Action. The claims are now cancelled rendering said rejection moot.

Claim 1 is rejected under 35 U.S.C. § 102(e) as being anticipated by the Shevy reference. Claim 1 is now cancelled rendering the rejection moot. However,

insofar as the subject matter of new claims 4-11 reflects that of the cancelled claim and in the event the Examiner considers asserting the present rejection against the new claims, applicants submit the following remarks.

The Office Action cites Fig. 4A of the Shevy reference. Fig. 4A shows a first amplifier 112B connected to a through line of coupler 102 which is connected to a through line of coupler 102A which in turn provides input to the second amplifier 112A. In contrast, the present invention requires "a second optical coupler, of a grating built-in type, having an input port, a through port *not* connected to the through port of the first optical coupler." This is in direct contrast to the arrangement of the Shevy device wherein the output of the amplifier 112B is directly connected to the input of the amplifier 112A by interconnection of through ports of the couplers.

In view of the above, it is respectfully submitted that the new claims particularly describe and distinctly claim elements not disclosed in the cited reference. Therefore, their allowance is respectfully requested.

Applicant respectfully requests a two month extension of time for responding to the Office Action. Please charge the fee of $205.00 for the extension of time to Deposit Account No. 10-1250.

Add-drop multiplexer with signal amplification ability

BACKGROUND OF THE INVENTION

The present invention is related to an optical coupler using a grating filter in which [[the]] a grating (periodic perturbation of refractive index) is formed in a core of an optical fiber and a portion adjacent the core [[thereof]].

~~It is thought that the~~ The present invention contributes in the field of optical communications. It is useful technology [[,]] when only specific wavelength is [[taken]] separated out or ~~it adds the signal of specific wavelength~~ or added in wavelength multiplex transmission ~~especially~~.

A ~~An optical~~ conventional optical transmission ~~penetration~~ type filter is described below.

Since it is generally common for the ~~penetrated typed~~ transmission optical filter to be required in the field of [[the]] optical communications, [[the]] an optical fiber grating filter ~~needed to be~~ is used ~~combining~~ in combination with optical parts including an optical circulator in order to [[make]] transmit a predetermined wavelength ~~zone penetrate~~ band. Fig. 8 illustrates a [[pattern]]

schematic diagram of [[the]] an optical fiber grating filter 22. Moreover, Fig. 9 illustrates the general reflective properties of the optical fiber grating filter 22. The optical fiber grating filter 22 formed in an optical fiber 21 is a filter of a reflection type which ~~has the feature which~~ reflects [[the]] light of a predetermined wavelength, ~~has the function to make other wavelength penetrate~~ allows transmission of other wavelengths, and is excellent in wavelength selection properties [[at]] for narrow band use, and ~~does not almost have~~ has little insertion loss. Although a usual reflective [[zone]] bandwidth is approximately lnm, if a special process is used, it can also realize ~~the reflective zone is~~ a reflective bandwidth of 0.2 mm to 10 mm.

Fig. 10 illustrates an example ~~which constituted the~~ an optical transmission filter ~~of a penetration type is shown~~ formed by combining an optical fiber grating filter 32 and optical circulator 33 in the course of an optical fiber 31. Although a signal incident from a port 1 is outputted to a port 2 if the optical fiber grating filter 32 is formed on the route to the port 2, only a specific wavelength (it is called wavelength λ B hereupon) is reflected and outputted from a port 3 after it returns back to the optical circulator 33 side. ~~Supposing it inputs~~ If two or more signals by which wavelength multiplex is carried out from the port 1, only [[the]] a signal corresponding to wavelength λB will be outputted from the port 3 and all the signals corresponding to other wavelength

will be outputted from the port 2. That is, the multiplex separation of the signal of specific wavelength λB can be carried out.

Moreover, Fig.11 illustrates ~~the example that constituted the~~ optical transmission filter ~~of a penetration type~~ formed by combining [[the]] an optical fiber grating filter 42 and an optical fiber coupler 43 in the course of an optical fiber 41. In this example, the signal inputted from the port 1 is outputted to the ports 3 and 4 by halves by the optical fiber coupler 43. [[In]] At the port 3 [[, it]] the signal is reflected [[with]] by the optical fiber grating filter 42 and the signal corresponding to wavelength λB reinputs to the optical fiber coupler 43, and [[it]] is outputted to the ports 1 and 2 by halves again. Therefore, one fourth of the inputted signals will be outputted in the port 2. ~~In this case, Supposing it inputs~~ If two or more signals are inputted to the port 1 by which wavelength multiplex is done ~~from the port 1~~, only the signal corresponding to wavelength λB will be outputted from the port 2, and all the signals corresponding to other wavelength will be outputted from the port 3.

In addition, Fig. 12 ~~illustrates the example that formed a rating~~ shows a grating filter 52 formed in extension part of an optical fiber coupler 53 ~~and constituted the optical filter of a penetration type~~ which functions as an optical transmission filter in the course of an optical fiber 51. In this example, ~~although the inputted~~ a signal ~~from the~~ input to port 1 [[by]] of the optical fiber coupler

53 ~~, if the rating~~ is reflected by a grating filter 52 is formed in an extension portion of the optical fiber coupler 53, ~~and only~~ if the signal is of specific wavelength λB ~~is reflected and is~~ , and will be outputted to the port 2. In this case, if two or more signals by which wavelength multiplex is done are inputted, the signal corresponding to the wavelength λB is outputted to the port 2, all signal corresponding to [[other]] another wavelength is outputted to the port 4 and the multiplex separation of the signal of specific wavelength λ B can be done.

The problem in the above-mentioned conventional technology is as follows.

At first, in the method shown in Fig. 10, in case of using the ~~combining~~ combination of the optical fiber grating filter 32 and the optical circulator 33, although the insertion loss is in approximately 2 dB between the port 1 and port 2, it is excelled in properties, the problem is that the optical circulator 33 is expensive. Moreover, in the method shown in Fig. 11 by the combination of the optical fiber grating filter 42 and optical fiber coupler 43, if the optical fiber coupler 43 is compared with the optical circulator 33, although it is a cheap device, as for insertion loss, the minimum is ~~also set to~~ 6dB (namely, 1/4). Furthermore, ~~the whole transmission~~ a signal outputted from the port 3 ~~carries out~~ has an insertion loss of 3 dB (namely, ½) ~~fall~~.

Furthermore, ~~Fig.12~~ by the combination of the optical fiber grating filter 52 and optical fiber coupler 53 shown in Fig. 12, the signal of specific wavelength λB that is outputted from the port 2 ~~outputted~~ to the port 1 and 4, the signal of specific wavelength λB outputted ~~carries out~~ has a 0.4 dB (namely, 9/10) ~~fall of the minimum~~ insertion loss.

SUMMARY OF THE INVENTION

In light of the forgoing, ~~it consists of~~ a multiplexer has a grating built-in type optical coupler and an optical amplifier, and [[has]] effects not only multiplex separation of a signal but ~~the function to add~~ addition of a specific wavelength, and the excitation light which became unnecessary can be removed effectively and it is enabled to suppress ~~the influence of~~ a fall of the signal light efficiency ~~to take out~~. Furthermore, since the device does not use optical parts, such as the above-mentioned optical circulator, and is ~~altogether constituted by~~ ~~the~~ formed by an optical fiber, ~~the affinity with a~~ transmission ~~way~~ is good. Accordingly ~~and~~ it is an object of the present invention to provide ~~a cheap~~ an inexpensive wavelength multiplex transmission system ~~by low connection~~ having a low insertion loss.

According to the invention, there is provided an add-drop multiplexer with signal amplification ability, comprising two optical ~~coupler~~ couplers of a grating built-in type with the two same structures and two optical amplifiers.

Moreover, the optical coupler of the grating built-in type of the present invention including ~~moltenextended~~ molten extended portion of fiber coupler formed [[in]] as a fiber grating, the pitch of the grating is a uniform structure in the length direction, apodization is carried out, and grating length is 2.0 mm and change in induced refractive index is 0.001. Here, apodization uses a window function for induced refractive index change of grating in the length direction of an optical fiber as shown in Fig.13.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 ~~is an explanation view showing~~ shows a first embodiment of the present invention;

Fig. 2 is a side view of a tapered optical fiber coupler showing the first embodiment of the present invention;

Fig. 3 is a sectional view of an optical fiber coupler melted and extended ~~showing~~ which is used in the first embodiment of the present invention;

Fig. 4 is a ~~view in properties~~ graph showing output power properties of Bragg wavelength to a port 2 of the first embodiment of the present invention;

Fig. 5 is a ~~view in properties~~ graph showing output power properties of exited light wavelength to a port 3 of the first embodiment of the present invention;

Fig. 6 is a ~~view in properties~~ graph showing properties in output wavelength (extension rate: 0.1; length of tapered portion: 20.5mm; and band of wavelength: 0.98 m) in the first embodiment of the present invention;

Fig. 7 is a ~~view in properties~~ graph showing properties in output wavelength (extension rate: 0.1; length of tapered portion: 20.5 mm; and band of wavelength: 1.55 μm) in the first embodiment of the present invention;

Fig. 8 is ~~an explanation~~ a schematic view of a conventional optical fiber grating filter;

Fig. 9 is a ~~view in properties~~ graph showing reflecting properties of a conventional optical fiber grating filter;

Fig. 10 is ~~an explanation~~ a schematic view showing an example of an optical filter combined with a conventional optical circulator;

Fig. 11 is ~~an explanation~~ a schematic view showing an example of an optical filter combined with a conventional fiber coupler;

Fig. 12 is ~~an explanation~~ a schematic view showing an example of an optical filter formed a grating at a melted-and-extended portion of a conventional optical fiber coupler; and

Fig. 13 is ~~an explanation~~ a schematic view showing an apodization in an optical fiber grating filter in another embodiment of the present invention.

DETAILED ~~DETAILE~~ DESCRIPTION

Preferred embodiments of the present invention are described in more detail below referring to the accompanying drawings.

Fig. 1 illustrates ~~the composition figure of the~~ an example of a first embodiment of the present invention. ~~This~~ A multiplexer comprises [[an]] first optical coupler 1 of the grating built-in type on an input side [[;]] of the multiplexer and an optical amplifier 2 ~~on an input side~~ having an output connected to one of through optical fibers 11 ~~on an input side, allowing signal light inputting; an~~ . A second optical [[couple]] coupler 1A of a grating built-in type is on an output side of the multiplexer and includes ~~including an other of optical fibers 11 on an input side~~ a coupled optical fiber 11A connected to ~~other of~~ a coupled optical ~~fibers~~ fiber 11A on an output side of the optical coupler 1 on the input side. ~~and providing without connecting one of the~~ The through optical fibers 11 ~~on an input side and one of the optical fibers 11 on an output~~

~~side; an~~ of couplers 1 and 1A are not connected to each other. A second optical amplifier 2A on an output side ~~connecting one of~~ receives input from the through optical ~~fibers~~ fiber 11 ~~on an output side~~ of the second optical ~~couple~~ coupler 1A. ~~on the output side, outputting signal light; and an connection~~ An optical fiber 13 connects ports of the coupled optical fibers through a switch 14 so as to output Bragg wavelength separated by the optical fiber 11A ~~on the input side~~ of the first optical coupler ~~on the input side~~ to other coupled optical fiber 11A on the output side of the second optical ~~couple~~ coupler 1A. ~~1 on the output side~~

In addition, means for inputting another Bragg wavelength maybe provided at the optical fibers 11A on an output side of other optical coupler lA ~~of grating built-in type on an output side~~. In Fig. 1, the signal light inputted from a left side is amplified with the optical amplifier 2, ~~it is~~ inputted into the port 1 of the optical fiber grating coupler 1 (left). Subsequently, only signal light corresponding to a Bragg wavelength of a [[rating]] grating of the coupler 1 is outputted by the port 2, and the other signal light is outputted to the port 4. Next, the outputted signal light optical is inputted into the port 4 of ~~a rating~~ the grating coupler (right) 1A provided symmetrically as compared to the left optical fiber grating coupler 1, and is further outputted to a port 1. Moreover, signal light corresponding to the Bragg wavelength is combined from the port 2,

and is outputted to the port 1. Therefore, all signal light becomes together, is again amplified by the optical amplifier of an output end, and acts to the main line. Then the excitation light used for each optical amplifier at this time outputs to the port 3 of the optical fiber grating coupler, and decreases.

Fig. 2 illustrates a side view of ~~the~~ an optical fiber coupler formed in a shape of a taper form and Fig. 3 illustrates a sectional view of the optical fiber coupler having a ~~moltenextended~~ molten extended portion. The numeral 11 shows an optical fiber; the numeral 12 is a filter having optical fiber grating; the mark of CO shows the width of two optical fibers without [[molting]] melting and extending; the mark of Cmin shows a width of the thinnest portion of optical fiber coupler which is molten-extended; Lc is a length of the taper portion of optical fiber coupler which is molten-extended (the length of the portion is not greater than 0.9 CO hereupon); and Lg is a length of the grating. Also it sets the ratio of CO and Cmin to extension ratio τ .

The method of producing the optical coupler of a grating built-in type shown in Fig. 1 is described as follows. At first, [[molting]] melting and extending of the two optical fibers 11 is carried out by the heating molten--extended method, and the optical fiber coupler is produced. Next, the formation position of the grating is determined. In this invention, the grating shall be symmetrically formed to the center of a taper part. Using the double luminous

flux holographic ~~interometry~~ interferometry or the phase mask method, the formation method of grating irradiates violet [[lays]] rays with a wavelength of about 244 nm from the side, and builds the [[on-the-strength]] stripes of irradiation light by interference. Since the induced refractive index of an optical fiber core part changes according to the intensity of violet [[lays]] rays, a grating is formed. In this embodiment, since the target signal wavelength is the ~~used as~~ 1.55 μm band, the pitch of interference fringes could be approximately 0.5 μm.

First, it is the optical fiber to which the used optical fiber 11 ~~added~~ has Ge (Germanium) added to the core, and [[added]] germanium and F (Fluorine) to [[crud]] to the cladding in production of the optical fiber coupler. The refractive index of the core and [[crud]] cladding of the optical fiber 11 are 1.4624 and 1.4580, respectively. ~~Produced~~ The optical fiber coupler produced is a coupler with wavelength dependability, for example, when the signal of wavelength the band of 1.55 micrometers is inputted from the port 1 shown in Fig.1, it is outputted to the port 4. The length Lc of the taper portion of the optical fiber coupler is approximately 20 mm. If the grating has a length of 2 mm, and an extension ratio is 0.1, [[o.15]] 0.15 and 0.2, in 15 and 0.2, the optical coupler of the grating built-in type is produced while the length of the taper of optical fiber coupler is changed. At this time, induced refractive index

change is set to 0.001. In each situation, the output efficiency of Bragg wavelength to the port 3 is shown in Fig. 4, and the excitation light is shown in Fig. 5 for the output efficiency to the port 2. The Bragg wavelength is set to 1.545 μm and the wavelength of excitation light wavelength is set to 0.98 μm .

When the extension ratio is 0.1 and a taper has a length of 20.5 mm, the output efficiency of Bragg wavelength to the port 2 is 67.6 %, and output efficiency of excitation light wavelength to the port 3 is 99.9 %. At this time, the output properties to the port 3 of 0.98 μm is shown in Fig. 6, the output property to the port 2 of 1.545 μm is shown in Fig. 7.

In result, by changing the form of the taper of coupler, the excitation light for optical amplification ~~removes~~ is removed up to about 100% , and it is enabled to combine or divide the signal light corresponding to Bragg wavelength out of the signal light amplified.

According to the present invention, as stated above, ~~it consists of~~ a multiplexer includes an optical coupler of the grating built-in type and optical amplifier and [has] effects not only multiplex separation of a signal but the function to add a specific wavelength. Accordingly, the excitation light that [[became]] is unnecessary can be removed effectively and ~~it is enabled to suppress the influence of a fall of~~ the signal light ~~efficiency to take out~~ insertion loss is minimized. Furthermore, since the device does not use the optical parts

including the above-mentioned optical circulator and is altogether constituted by the optical fiber, ~~the affinity with a~~ transmission ~~way~~ is good and ~~it is~~ an object of the present invention to provide ~~a cheap~~ an inexpensive wavelength multiplex transmission system ~~by low connection loss~~ having low insertion loss is achieved.

ABSTRACT

~~Using grating~~ Grating built-in type optical fiber ~~coupler~~ couplers and ~~an~~ optical ~~amplifier~~ amplifiers form a multiplexer for efficiently effecting [[,]] multiplex separation of [[the]] a specific wavelength ~~efficient is done~~ without using an optical circulator. ~~etc., and the~~ A function to add [[the]] a signal of specific wavelength efficiently can be realized. ~~In addition, it is in offering the wavelength multiplex transmission system that obtains a device cheaply.~~ Additionally, the device is inexpensive.